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Tribology : A Potential Source of Energy Savings in Industry

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Introduction

In this juncture of global industrialization the need of the hour is to stimulate the industrial growth at the same time to protect the global environment. Simultaneously the most important consideration in today's global industrialization is to save energy by judicious selection and control of the processes as well as to search and use of alternative sources of energy where possible.

The chief source of energy in our country is mainly thermal power and the lubricants produced mainly from petroleum products. All these are natural resources and it is needless to mention that the natural sources of energy are gradually diminishing at a rapid rate. In the recent time various researches are going on regarding different alternative energy sources, many of them are implemented effectively and going to be implemented. However, in industry specific cases and from practicality point of view alternative sources of energy have several constraints and thus the natural sources of energy are quite inevitable till date, particularly in large and medium sized industries. The very important question is thus, how to use the conventional energy sources very effectively? In this present paper light is shed on the potential sources of energy savings in industries from tribological point of view.

Tribology : A brief history

Tribology is a subject related to the science and engineering of interactive surfaces in relative motion. The phenomenon was known in the human race in the past several years, however the term tribology, superimposition of two Greek words 'tribos' (rubbing) and 'logos' (principle or logic), was coined only during 1966 by an UK committee headed by Professor Duncan Dowson. It is not out of place to mention here that one of the most significant landmarks in the history of tribological conquest in the United Kingdom was the publication of long research findings of Prof. (Dr.) Peter Jost in the year 1966. Not only in UK, that report paved the path of further tribological researches throughout the globe.

The sculptures on the tomb at Saqquara reveals the use of lubricants in a sledge. As shown in figure1, an Egyptian, bending down in posture, is pouring a liquid on the motion path of the sledge, that is, lubricating the sledge which is carrying a statue. This man is considered as the first 'tribologist'. In that curving it is observed that 172 men, most likely the slaves, are pulling a large statue weighing 600 KN. Later on Dowson (1998) estimated that total effort in that work was approximately 172 × 800 N, considering, each man was exerting a pull of about 800 N. Hence the coefficient of friction was approximately 0.23.

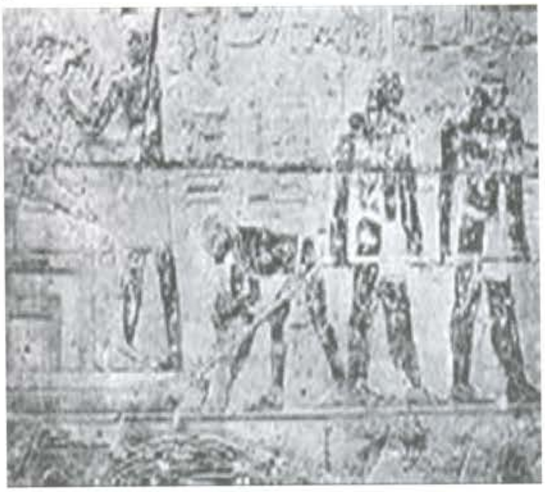

Fig. 1. Statue is carried on and the sledge is lubricated by an Egyptian.

Evidences are there which indicate the use of a mixture of olive oil and lime to lubricate chariot wheel during 1400 B.C. A figure of chariot is depicted in figure 2. War ships, recovered from Nemi Lake (c. 50 AD) near Rome, Italy, were also equipped with bronze rollers and balls to support the revolving platforms. Leonardo da Vinci (1452–1519), the famous painting personality, also studied about friction and sketched figures in that regard as depicted in figure 3. Marine chronometers designed by John Harrison (1693–1776) were based mainly on the tribological principle. A figure of the device is shown in figure 4.

Fig. 2. Picture of chariot during 1400 B.C.

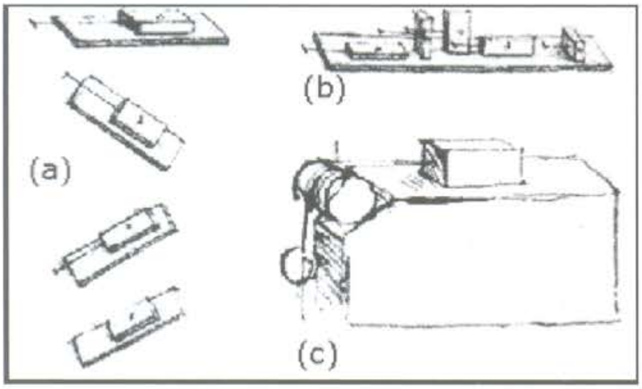

Fig. 3. Leonardo da Vinci's sketches regarding studies on friction.

Fig. 4. Marine Chronometer.

There are many more examples and all these prove the fact that the role and importance of tribology is not new. However, today's development in the area of tribology is quite complex to meet the requirement of machine specific applications. There are various developments, experiments so on and so forth. Still it is a complex phenomenon, not well understood and ill propagated too.

It is not out of place to mention why we should consider the role of tribology. On an average, $1/3^{rd.}$ of the total energy is lost due to friction and wear [STLE, US]. These loses ultimately cost the consumers at large. The loss is estimated at \$200 billion in US alone. Not only the monetary losses but tribology related losses also impair the product life cycle as well as quality, reliability, safety, environment at large and many more.

Industry specific cases

Loss of energy due to friction as well as loss of materials due to wear ultimately lead to monetary loss. The tribology related loss, in general, occurs where two or more interacting surfaces are present under relative motion. However, in this section, some industry specific cases will be discussed in brief.

3.1 Automobile

In automobiles the potential sources of energy loss due to friction are

(i) the cylinders and piston rings – 25 to 50% of mechanical losses.
(ii) transmission – 75% of input energy is lost.
(iii) lubricants – not estimated.

In these calculations thermal efficiency of petrol engine and diesel engine is considered as 25-28% and 33 – 37% respectively. Saving of energy that is possible in the above three cases are estimated at 9 – 12%, 25 – 30% and 1.3 – 5% respectively. It is thus observed that maximum savings of energy is possible during transmission.

3.2 Power Plant

Loss prone areas in a power plant are

(i) various bearings – 4.2% of the out put.
(ii) turbine leakage – 2 – 4% of the out put.
(iii) pump seals – 4.5% of the out put.

Estimated potential savings in the above cases are 15 – 20%, 50% and 10% respectively. From the data it reveals that though the turbine leakage loss is not maximum but the saving potential is maximum in this area.

3.3 Manufacturing

Enormous loss due to machining is associated with different manufacturing operations like forging, casting, rolling, extrusion, metal cutting etc. and the magnitude of the losses are not estimated, at least there is no such authentic source of reference in this regard.

Irrespective of the type of industries and machining operations it is important to note that a proper machine criticality based assessment and ranking of the machines is the starting point for proper lubrication planning which ultimately will reduce friction as well as wear of the materials. Reduced friction will minimize the energy loss at large. The criticality assessment is a thorough scientific study based primarily on the following sequential steps:

(I) machine failure risk to employees, customers and environment at large

(ii) machine failure risk to production quality
(iii) rate of failure, mean time between failures, operating cycles etc
(iv) machine function in details
(v) hourly value of machine function
(vi) speed of failure
(vii) cost of machine repair
(viii) severity of the operating environment.

Operating environment severity includes but not limited to the factors like, atmospheric temperature, humidity, presence of dirt and dust, direct exposure of the machine to production chemicals, moisture or solid contaminants, machine stability and like others. Based on the criticality studies machines are ranked accordingly and then detail studies of the sources of tribological disturbances are initiated. All the lubricated components like bearings, couplings, gears, pumps, compressors etc. are studied in detail in this step. Having a complete break up of different components a proper lubrication plan is then carried out. It is not out of place to mention here that in the majority of the cases lubrication is not considered with its due weightage. It is not taken as a serious technical task. As a result sometimes proper lubrication is not met or sometimes parts are over lubricated which leads to the wastage of the lubricants which again is not justified in this era of energy crisis. Lubricants are toxic also in different cases. Thus over lubrication may also lead to some serious health hazard to the workers in the industry and the environment at large. Proper lubrication is thus a faculty which is to be nurtured with great care considering the roll of tribology.

Economic implication and savings potential

Improved tribological practice has the major savings potentials as indicated in table 1 below:

Table 1.

Maintenance and parts replacemen	45%
Losses due to machine breakdown	22%
Investment though increased availability & higher efficiency	4%
Increased overall plant life	20%

Truly speaking the thought process of tribology and the dire necessity of proper machine lubrication came into the picture during mid 1960's only when British Professor (Dr.) Peter Jost published his research findings for the first time about the influence of poorly executed lubrication practice in different industrial applications in Great Britain. His prediction about the potential savings that could be achieved by executing proper lubrication and maintenance tribology practice is summarized in table 2 below:

Table 2.

Maintenance and repair cost	20%
Lube procurement	20%
Reduced energy requirement (due to controlled friction)	7.5%
Reduced machine purchase cost	5%
Utilization of efficiency	1%
HR savings due to reduced repairs	0.13%

Estimated potential savings in US $ of more than 10 billion (103.61 hundred million USD) is given in table 3. This is based on the findings of the CAE (Chinese Academy of Engineering) investigation in 6 industrial areas during November 2006.

Table 3.

Metallurgical Industry	13.17
Energy (coal, electric power) and petrochemical industries	5.63
Railway Transport	7.77
Automotive Industry	69.85
Agricultural Machinery	1.77
Shipping Industry	5.42
SUM TOTAL	103.61

In the following table, country-wide losses and savings potentials due to tribological consequences are depicted:

Table 4.

Study Report by	**National Loss/yr** (in billion)	**Savings Potential/yr** (in billion)
UK 1966, Jost Report	£2	£0.51, 25% of total loss
FRG 1976,	DM 10	DM 5, 50% of total loss
USA 1979, ASME Report	$ 100	$ 16
USA 1985	$ 200	-
Germany 1983	DM 38.71	DM 0.62
India 1998	Rs. 400	Rs. 70

Conclusion

Friction and wear of materials due to ill tribological consequences will lead to the direct and immediate loss of energy. Considering the worldwide experience in the field of tribology it is estimated that savings up to 20% of the gross national products can be achieved by paying proper attention specially in the area of education, research and application. This effect is achieved without any significant investment.

Different survey highlighted the relative increase in the cost of conventional energy arising from the energy crisis worldwide and the total reserve of the natural resources are also diminishing gradually. This initiates the dire necessity of energy conservation and use of alternative sources of energy. Good tribological practice can save energy logically and the loss of material, failure of machine parts are also reduced due to reduced friction and wear which is achieved by judicious use of lubricants.

Thus, in this juncture of worldwide energy related thinking, the need of the hour is to nurture a good and logical tribolgy related practice in the industrial sectors too for the sake of energy savings and better utilization of resources.

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